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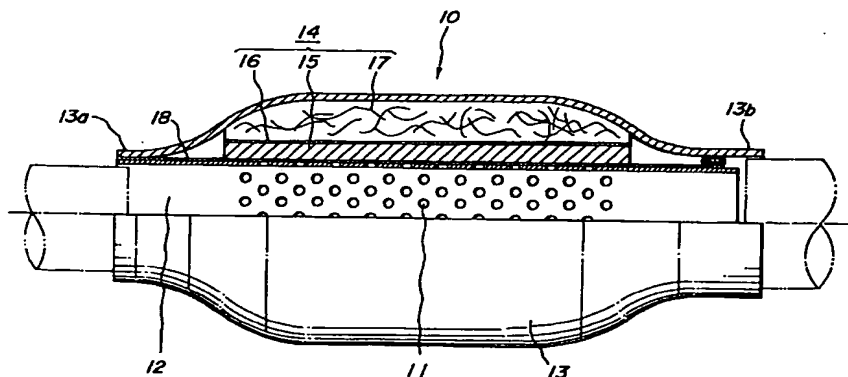
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**(54) MUFFLER FOR AN INTERNAL COMBUSTION ENGINE**

(57) The invention provides a muffler for internal combustion engine having excellent durability (resistance to scattering) even when being exposed to a high-temperature exhaust gas and capable of maintaining high sound absorption coefficient over a long period.

Such a muffler comprises a metal tube provided with a plurality of small holes, an inorganic fiber sound absorbing material arranged on the outer periphery thereof and a metal shell covering the outside of the

sound absorbing material, in which a scattering prevention member is disposed between the metal tube and the sound absorbing material. The sound absorbing material is a laminated structure of crystalline alumina fiber mat and glass fiber mat. As the scattering prevention member, there is used a stainless woven wire cloth, a woven fabric made from inorganic fiber and a metal foil.

**FIG.2**

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increases and also the cost increases.

### Disclosure of the Invention

5 It is an object of the invention to solve the aforementioned problems and to provide a muffler for internal combustion engine having an excellent durability (resistance to scattering) even when being exposed to the high-temperature exhaust gas, and maintaining the air tightness in the joint portion between the metal tube and the metal shell without being influenced by the thermal expansion difference therebetween and capable of maintaining the high sound absorption coefficient over a long period.

10 The invention lies in a muffler for internal combustion engine comprising a metal tube provided with a plurality of small holes, an inorganic fiber sound absorbing material arranged on an outer periphery thereof and a metal shell covering an outside of the sound absorbing material, characterized in that a scattering prevention member is disposed between the metal tube and the sound absorbing material, and the sound absorbing material has a lamination structure that a crystalline alumina fiber mat containing not more than 10 wt% of granulated substance of not less than 44  $\mu\text{m}$  and having an average fiber size of 3.5-10  $\mu\text{m}$  is arranged on an outer periphery of the scattering prevention member at a filling density of 0.05-0.30  $\text{g/cm}^3$  and a glass fiber mat is laminated on an outer periphery of the crystalline alumina fiber mat at a filling density of 0.10-0.30  $\text{g/cm}^3$ .

In a preferable embodiment of the invention, the scattering prevention member is selected from a stainless woven wire cloth, a woven fabric made from inorganic fiber and a metal foil.

20 In the muffler according to the invention, the scattering prevention member is arranged between the metal tube and the sound absorbing material instead of the stainless wool used in the conventional muffler, so that the sound absorbing material can be protected from pressure shock concentrating in the small holes of the metal tube accompanied with the passage of the high-temperature exhaust gas and also noise components passed through the small holes can effectively be absorbed by the sound absorbing material.

25 Since the crystalline alumina fiber mat having excellent heat resistance and heat insulating property is wound around the metal tube as a sound absorbing material, heat conduction to the glass fiber mat laminated on the outer peripheral portion thereof is controlled and hence the degradation of the glass fiber due to heat of the exhaust gas is prevented and the scattering of the fiber due to vibration and pulsation of the exhaust gas is not caused. Furthermore, the crystalline alumina fiber mat is superior in the sound absorptivity to the stainless wool, so that the muffler can be compacted.

### Brief Description of the Drawings

Fig. 1 is a partly developed plan view of the conventional muffler.

35 Fig. 2 is a plane view partly shown in section of an embodiment of the muffler according to the invention.

Figs. 3 and 4 are partly developed plan views of the other embodiments of the muffler according to the invention, respectively.

Fig. 5 is a diagrammatic view illustrating an assembling method of the muffler shown in Fig. 2.

### Best Mode for carrying out the Invention

The invention will be described in detail with reference to Fig. 2, Fig. 3, Fig. 4 and Fig. 5 below. In these figures, the same member is represented by the same numeral.

45 A first embodiment of the muffler according to the invention is shown in Fig. 2. This muffler 10 comprises a metal tube 12 provided with a plurality of small holes 11, a metal shell 13, a sound absorbing material 14 filled in a space between the metal tube 12 and the metal shell 13 and having a lamination structure of a crystalline alumina fiber mat 15, a stainless woven wire cloth 16 and a glass fiber mat 17, in which a stainless woven wire cloth 18 is disposed between the metal tube and the sound absorbing material as a scattering prevention member for the sound absorbing material.

50 The metal shell 13 is not particularly restricted to the illustrated shape as far as a space filling the sound absorbing material 14 is defined between the metal shell and the metal tube 12, but it is necessary that a size of opening portions 13a and 13b at both ends of the metal shell 13 is made slightly larger than an outer diameter of the metal tube 12. Further, it is important that either the opening portion 13a or 13b, e.g. the opening portion 13a in the illustrated embodiment is fixed to the metal tube 12, for example, by welding and the remaining opening portion 13b is not fixed thereto.

55 The stainless woven wire cloth 18 as the scattering prevention member arranged on the outer periphery of the metal tube 12 between the metal tube 12 and the sound absorbing material 14 is fixed at its one end to either the metal tube 12 or the metal shell 13 or both in the opening portion 13a. Further, the other end of the stainless woven wire cloth 18 is folded by at least one turn to render into a thickness corresponding to a gap between the opening portion 13b of

The crystalline alumina fiber mat constituting a part of the sound absorbing material used in the muffler according to the invention and arranged on the outer periphery of the scattering prevention member will be described below. The crystalline alumina fiber constituting the mat is different from the general-purpose crystalline alumina fiber used in the conventional muffler and is alumina fiber having an alumina content of 72-85%, a silica content of 15-28%, an average fiber size of 3.5-10  $\mu\text{m}$ , preferably 4.5-6.5  $\mu\text{m}$  and containing not more than 10 wt% of granulated substance of not less than 44  $\mu\text{m}$ .

In such a crystalline alumina fiber, when the alumina content is higher than 85%, the true specific gravity of the fiber is high and the porosity is large, so that the pressure drop is low and the sound absorptivity lowers. Further, when the silica content is higher than 28%, silica crystal is liable to be existent and the strength of the fiber lowers. And also, when the average fiber size is less than 3.5  $\mu\text{m}$ , the pressure drop becomes higher and the sound absorption coefficient at a high frequency side lowers. While, when the average fiber size exceeds 10  $\mu\text{m}$ , the pressure drop becomes lower and the sound absorption coefficient at a low frequency side lowers. Moreover, when the content of granulated substance of not less than 44  $\mu\text{m}$  is more than 10 wt%, the granulated substance or shot is moved in the crystalline alumina fiber mat by vibrations to form spaces in the mat likewise the aforementioned silica-alumina ceramic fiber.

The crystalline alumina fiber mat used in the invention is a mat formed by filling the crystalline alumina fiber at a filling density of 0.05-0.30  $\text{g/cm}^3$ , preferably 0.20-0.25  $\text{g/cm}^3$ . When the filling density is less than 0.05  $\text{g/cm}^3$ , there is a problem in the durability of the mat, while when the filling density exceeds 0.30  $\text{g/cm}^3$ , the sound damping effect is degraded and also the insertion into the metal shell is considerably difficult.

As the glass fiber mat constituting a part of the sound absorbing material according to the invention and covering the outer periphery of the crystalline alumina fiber mat, there is used a mat having a filling density of 0.10-0.30  $\text{g/cm}^3$ .

When the filling density of the glass fiber is less than 0.10  $\text{g/cm}^3$ , there is caused a problem in the durability, while when the filling density exceeds 0.30  $\text{g/cm}^3$ , the sound damping effect is degraded and also the insertion into the metal shell is difficult.

In the sound absorbing material 14 having a lamination structure of the crystalline alumina fiber mat and the glass fiber mat as shown in Figs. 2-4, a stainless woven wire cloth 16 is wound on the outer periphery of the crystalline alumina fiber mat 15 for adjusting the filling density of each mat to a given value.

The glass fiber mat is usually formed by needling, so that the elastic force of the fiber is controlled. On the other hand, the crystalline alumina fiber mat increases the repulsive force as the filling density becomes high. Therefore, even if the filling density is set to crystalline alumina fiber mat: 0.20  $\text{g/cm}^3$  and glass fiber mat: 0.30  $\text{g/cm}^3$ , when the laminate of these mats is actually mounted in the muffler without the stainless woven wire cloth, the glass fiber mat is crushed by the crystalline alumina fiber mat, whereby the filling density is changed into crystalline alumina fiber mat: 0.18  $\text{g/cm}^3$  and glass fiber mat: 0.32  $\text{g/cm}^3$ , respectively, and hence the resulting muffler may not be used because the filling density is outside the given range.

Therefore, it is preferable to wind the stainless woven wire cloth on the outer periphery of the crystalline alumina fiber mat. The stainless woven wire cloth is required to select ones having a heat resistance and being not deformed by elastic force of the crystalline alumina fiber mat.

Such a stainless woven wire cloth is made from SUS304, SUS430 or the like and is favorable to have a wire diameter of 0.1-1 mm and a net of 5-50 mesh.

Moreover, the filling thickness of the crystalline alumina fiber mat and glass fiber mat is determined by setting the filling thickness of the crystalline alumina fiber mat. That is, the heat-resistant temperature of the glass fiber is usually 600-800°C, so that it is necessary to set the filling thickness of the crystalline alumina fiber mat so as to render a temperature applied to the glass fiber mat into not higher than 600°C.

A method of assembling the crystalline alumina fiber mat and the glass fiber mat will be described below.

In the assembling of these mats, there are, for example, the following two methods. A first method is a method of using the crystalline alumina fiber mat and the glass fiber mat each packed with a plastic film under vacuum. In the first method, each vacuum-packed mat is successively wound around the metal tube and then assembled into the inside of the metal shell. A second method is a method of using a sub-assembled product formed by winding the stainless woven wire cloth 18 as a scattering prevention member and a laminate of crystalline alumina fiber mat 15, stainless woven wire cloth 16 and glass fiber mat 17 as a sound absorbing material 14 around the metal tube 12 and placing in a bag 34 of a plastic film. In the second method, the sub-assembled product is inserted into the metal shell 13 up to a given position while deaerating the inside of the bag 34 through a hose 36.

In the conventional muffler, the surface of the glass fiber mat is subjected to a curing treatment with an inorganic binder for facilitating the shape-holding and assembling of the mat. In this case, however, the elasticity of the glass fiber mat is damaged to lower the sound absorption coefficient. According to the invention, the assembling of the glass fiber mat is carried out by the aforementioned method without surface curing.

As the plastic film, there are plastic films made from silicone resin, polyvinyl chloride, polyethylene, ionomer resin and the like. Particularly, it is desirable that the surface of the plastic film has a good lubricity in order to facilitate the insertion into the inside of the metal shell. That is, the plastic film is desirable to be made from a material having a low

shown in Table 1.

[Example 5]

5 A muffler 30 having a structure shown in Fig. 4 by repeating the same procedure as in Example 1. In this case, a metal foil 46 of SUS304 having a surface density of  $0.16 \text{ kg/m}^2$  instead of the stainless woven wire cloth as the scattering prevention member. The same measurement as in Example 1 is carried out with respect to this muffler 30. The results are shown in Table 1.

10 [Comparative Example 1]

A muffler is prepared by repeating the same procedure as in Example 1 without using the stainless woven wire cloth as the scattering prevention member, and the noise is measured in the same manner as in Example 1. The results are shown in Table 1.

15

[Comparative Example 2]

A muffler 1 having a structure shown in Fig. 1 is prepared. In this case, the metal tube 2 and the metal shell 3 are the same as in Example 1. A glass fiber mat 5 having an average fiber size of  $9 \mu\text{m}$ , a filling density of  $0.16 \text{ g/cm}^3$  and a thickness of  $18 \text{ mm}$  is used as the sound absorbing material, and a stainless wool 6 (wire diameter:  $70 \mu\text{m}$ , SUS430) is arranged in the side of the metal tube 2 at a filling density of  $0.56 \text{ g/cm}^3$  and a thickness of  $5 \text{ mm}$  as a scattering prevention member for the sound absorbing material. The same measurement as in Example 1 is carried out with respect to this muffler 1. The results are shown in Table 1.

25 [Comparative Example 3]

A muffler is prepared by repeating the same procedure as in Example 1 except that a crystalline alumina fiber mat having an average fiber size of  $2.9 \mu\text{m}$ , a filling density of  $0.24 \text{ g/cm}^3$  and a thickness of  $10 \text{ mm}$  is used. The same measurement as in Example 1 is carried out with respect to this muffler. The results are shown in Table 1.

30

[Comparative Example 4]

A muffler is prepared by repeating the same procedure as in Example 1 except that a crystalline alumina fiber mat having an average fiber size of  $4.3 \mu\text{m}$ , a filling density of  $0.32 \text{ g/cm}^3$  and a thickness of  $10 \text{ mm}$  is used. The same measurement as in Example 1 is carried out with respect to this muffler. The results are shown in Table 1.

35

[Comparative Examples 5-7]

A muffler is prepared by repeating the same procedure as in Example 4 except that kind of the woven fabric as the scattering prevention member and the number of each of the wefts and warps per  $25 \text{ mm}^2$  of the woven fabric are changed as shown in Table 2. The measurement of noise before the actual running is carried out in the same manner as in Example 1. The results are shown in Table 2 together with the result of Example 4.

40

[Comparative Examples 8-10]

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A muffler is prepared by repeating the same procedure as in Example 5 except that kind and thickness of the metal foil are changed as shown in Table 3. The measurement of noise before the actual running is carried out in the same manner as in Example 1. The results are shown in Table 3 together with the result of Example 5.

50

55

Table 3

	Metal foil		Noise value (dB)
	Kind	Surface density (kg/m <sup>2</sup> )	
Example 5	SUS304	0.16	75.9
Comparative Example 8	aluminum	0.32	78.5
Comparative Example 9	SUS304	0.40	80.3
Comparative Example 10	aluminum	0.40	79.8

The peculiar action and effect of the muffler according to the invention are mentioned as follows.

(a) In the muffler according to the invention, the stainless woven wire cloth, inorganic fiber woven fabric or metal foil is used as the scattering prevention member instead of the stainless wool used in the conventional muffler, and the crystalline alumina fiber mat having excellent heat resistance and heat insulating property is wound thereon as a part of the sound absorbing material.

Therefore, thermal conduction to the glass fiber mat further wound as a part of the sound absorbing material is controlled and hence the degradation of the glass fiber mat due to heat of the exhaust gas is prevented. And also, the scattering of the sound absorbing material due to pulsation of the exhaust gas can be prevented by the scattering prevention member. Furthermore, since the content of granulated substance of not less than 44  $\mu\text{m}$  is restricted to not more than 10 wt%, the movement of shot in the inside of the crystalline alumina fiber mat due to vibration is prevented.

(b) The crystalline alumina fiber mat is excellent in the sound absorptivity as compared with the stainless wool, so that the muffler can be compacted.

(c) In order to mitigate the thermal expansion difference produced between the metal tube and the metal shell, when the stainless woven wire cloth is used as the scattering prevention member instead of the stainless gasket used in the conventional muffler, an end of the stainless woven wire cloth is folded by at least one turn and disposed in the gap between the metal tube and the metal shell, whereby the buckling due to compression of the metal tube based on the thermal expansion difference, the peeling of weld portion and the like are prevented, and hence the step of previously welding the gasket to the metal shell as in the conventional technique is useless and the muffler can be assembled cheaply and easily.

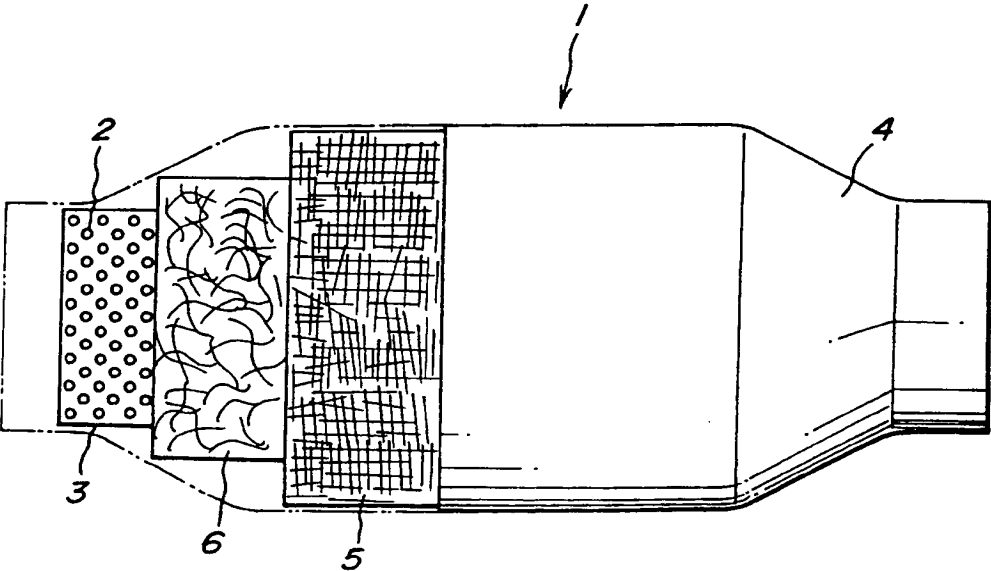
#### Industrial Applicability

According to the invention, there can be provided a muffler for internal combustion engine, particularly automobile engine having excellent resistance to scattering even when being exposed to a high-temperature exhaust gas and capable of maintaining high sound absorption coefficient over a long period.

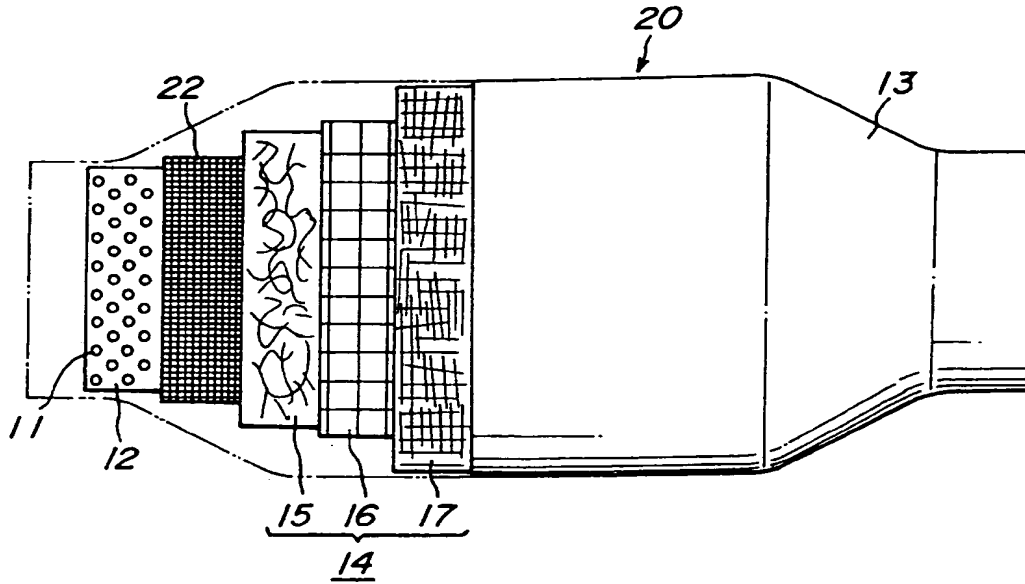
#### **Claims**

1. A muffler for internal combustion engine comprising a metal tube provided with a plurality of small holes, an inorganic fiber sound absorbing material arranged on an outer periphery thereof and a metal shell covering an outside of the sound absorbing material, characterized in that a scattering prevention member is disposed between the metal tube and the sound absorbing material, and the sound absorbing material has a lamination structure that a crystalline alumina fiber mat containing not more than 10 wt% of granulated substance of not less than 44  $\mu\text{m}$  and having an average fiber size of 3.5-10  $\mu\text{m}$  is arranged on an outer periphery of the scattering prevention member at a filling density of 0.05-0.30 g/cm<sup>3</sup> and a glass fiber mat is laminated on an outer periphery of the crystalline alu-

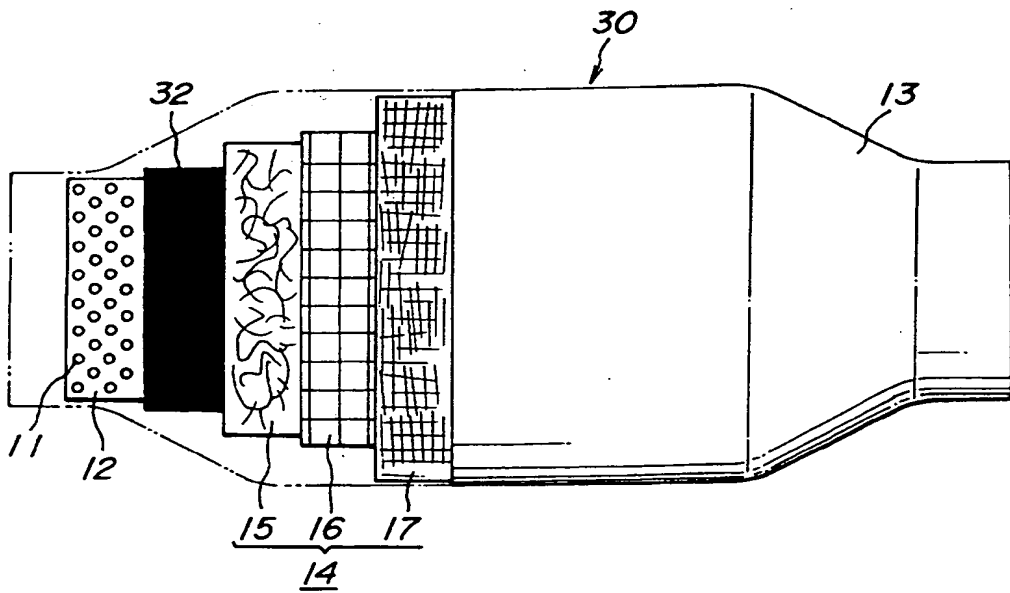
FIG. 1



**FIG. 3**



**FIG. 4**



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP96/02732

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>		
Int. Cl <sup>6</sup> F01N1/24		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols)		
Int. Cl <sup>6</sup> F01N1/24, F01N1/04, F01N7/14		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Jitsuyo Shinan Koho 1926 - 1996		
Kokai Jitsuyo Shinan Koho 1971 - 1996		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CD-ROM of the specification and drawings annexed to the written application of Japanese Utility Model Application No. 13759/1992 (Laid-open No. 66210/1993) (K.K. Honda Gijutsu Kenkyusho), September 3, 1993 (03. 09. 93), Paragraphs 12 to 15; Fig. 3 (Family: none)	1
Y	Microfilm of the specification and drawings annexed to the written application of Japanese Utility Model Application No. 33194/1989 (Laid-open NO. 126014/1990) (Nissan Motor Co., Ltd., Nippon Leinz K.K.), October 17, 1990 (17. 10. 90), p.81.1-p.81.11; table 1 (Family: none)	1 - 3
Y	Microfilm of the specification and drawings annexed to the written application of Japanese Utility Model Application No. 33127/1991 (Laid-open NO. 127824/1992) (Calsonic Corp.), November 20, 1992 (20. 11. 92),	1-2, 4
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "A" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
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